

## Pre-Lab Discussion

There are many kinds of chemical reactions and several ways to classify them. One useful method classifies reactions into four major types. These are: (1) direct combination, or synthesis; (2) decomposition, or analysis; (3) single replacement; and (4) exchange of ions, or double replacement. Not all reactions can be put into one of these categories. Many, however, can.

In a synthesis reaction, two or more substances (elements or compounds) combine to form a more complex substance. Equations for synthesis reactions have the general form  $A + B \rightarrow AB$ . For example, the formation of water from hydrogen and oxygen is written  $2H_2 + O_2 \rightarrow 2H_2O$ .

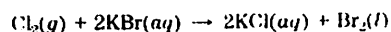
A decomposition reaction is the opposite of a synthesis reaction. In decomposition, a compound breaks down into two or more simpler substances (elements or compounds). Equations for decomposition reactions have the form  $AB \rightarrow A + B$ . The breakdown of water into its elements is an example of such a reaction:  $2H_2O \rightarrow 2H_2 + O_2$ .

In a single replacement reaction, one substance in a compound is replaced by another, more active, substance (an element). Equations for single replacement reactions have two general forms. In reactions in which one metal replaces another metal, the general equation is  $X + YB \rightarrow XB + Y$ . In those in which one nonmetal replaces another nonmetal, the general form is  $X + AY \rightarrow AX + Y$ . The following equations illustrate these types of reactions:

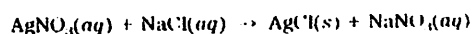
Zinc metal replaces copper(II) ion:



Chlorine (a nonmetal) replaces bromide ions:



In a double replacement reaction, the metal ions of two different ionic compounds can be thought of as "replacing one another." Equations for this type of reaction have the general form  $AB + CD \rightarrow AD + CB$ . Most replacement reactions, both single and double, take place in aqueous solutions containing free ions. In a double replacement reaction, one of the products is a precipitate, an insoluble gas, or water. An example is the reaction between silver nitrate and sodium chloride in which the precipitate silver chloride is formed:



All of the types of reactions discussed here may be represented by balanced molecular equations. Reactions involving ion exchanges may be represented by ionic equations also. In this investigation you will be concerned only with molecular formulas and equations. In a balanced equation, the number of atoms of any given element must be the same on both sides of the equation. Multiplying the coefficient and the subscript of an element must yield the same result on both sides of the balanced equation.

In this investigation you will observe examples of the four types of reactions described above. You will be expected to balance the equations representing the observed reactions.

## Purpose

Observe some chemical reactions and identify reactants and products of those reactions. Classify the reactions and write balanced equations.

## Equipment

burner  
crucible tongs  
microspatula  
test tubes, 15 × 180-mm (7)  
test tube holder  
test tube rack

wood splints  
sandpaper, fine  
evaporating dish  
safety goggles  
lab apron or coat

## Materials

zinc, mossy (Zn)  
copper wire, 10 cm (Cu)  
magnesium ribbon, 5 cm (Mg)  
copper(II) carbonate ( $CuCO_3$ )  
6 M hydrochloric acid (HCl)

1 M copper(II) sulfate ( $CuSO_4$ )  
0.1 M zinc acetate ( $Zn(C_2H_3O_2)_2$ )  
0.1 M sodium phosphate ( $Na_3PO_4$ )  
1 M sodium sulfite ( $Na_2SO_3$ )

## Safety



In this investigation you will be working with open flames, heating chemicals, handling acids, and producing gaseous products. You should review the safety procedures for these activities given on pages ix–x.

Burning magnesium produces a very bright, hot flame. Make sure you hold the burning metal at arm's length and do not look directly at it.

Remember never to smell a chemical directly. Review the accepted method of wafting gases toward your nose as illustrated on page xi.

Pay special attention to the safety symbols beside certain steps in the procedure. Refer to page xi to review the special precautions associated with each symbol.

Wear safety goggles and protective clothing at all times when working in the lab.

## Procedure

### PART A SYNTHESIS

1. Use fine sandpaper to clean a piece of copper wire until the wire is shiny. Note the appearance of the wire.



2. Using crucible tongs, hold the wire in the hottest part of a burner flame for 1–2 minutes. Examine the wire and note any change in its appearance caused by heating.

3. Place an evaporating dish near the base of the burner. Examine a piece of magnesium ribbon. Using crucible tongs, hold the sample in the burner flame until the magnesium starts to burn. **DO NOT LOOK DIRECTLY AT THE FLAME. HOLD THE BURNING MAGNESIUM AWAY FROM YOU AND DIRECTLY OVER THE EVAPORATING DISH.** When the ribbon stops burning, put the remains in the evaporating dish. Examine this product carefully.

### PART B DECOMPOSITION



4. Place 2 heaping microspatulas of copper(II) carbonate ( $CuCO_3$ ) in a clean, dry test tube. Note the appearance of the sample.

5. Using a test tube holder, heat the  $CuCO_3$  strongly for about 3 minutes. Extinguish the flame and then insert a *burning* wood splint into the test tube. If carbon dioxide gas ( $CO_2$ ) is present, it will put the flame out. Note any change in the appearance of the residue in the test tube.

## PART C SINGLE REPLACEMENT



6. Stand a clean, dry test tube in the test tube rack. Add about 5 mL of 6 M hydrochloric acid (HCl) to the tube. **CAUTION.** Handle acids with care. They can cause painful burns. Do not inhale any HCl fumes. Now carefully drop a small piece of zinc metal (Zn) into the acid in the test tube. Observe and record what happens.

7. Using a test tube holder, invert a second test tube over the mouth of the test tube in which the reaction is taking place. See Figure 14-1. Remove the inverted tube after about 30 seconds and quickly insert a burning wood splint into the mouth of the tube. (A "pop" indicates the presence of hydrogen gas.) Note the appearance of the substance in the reaction test tube.

8. Add about 5 mL of 1 M copper(II) sulfate ( $\text{CuSO}_4$ ) solution to a clean, dry test tube. Place a small amount of zinc metal in the solution. Note the appearance of the solution and the zinc before and after the reaction.

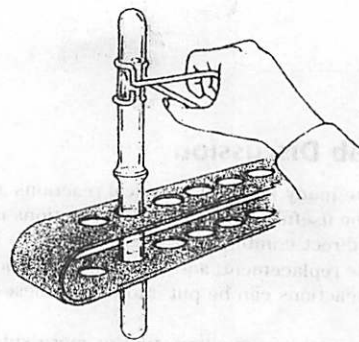


Figure 14-1

## PART D DOUBLE REPLACEMENT



9. Add about 2 mL of 0.1 M zinc acetate ( $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2$ ) to a clean, dry test tube. Next, add about 2 mL of 0.1 M sodium phosphate tribasic ( $\text{Na}_3\text{PO}_4$ ) solution to the test tube. Observe what happens and note any changes in the mixture.

10. Add about 5 mL of 1 M sodium sulfite ( $\text{Na}_2\text{SO}_3$ ) solution to a clean, dry test tube. To this solution, add about 1 mL of 6 M HCl. Note the odor given off by wafting some of the gas toward your nose. DO NOT SMELL THE GAS DIRECTLY.

## Observations and Data

### DATA TABLE

Sample	Before reaction	After reaction
<b>A. Synthesis</b>		
1. Cu		
2. Mg		
<b>B. Decomposition</b>		
3. $\text{CuCO}_3$		
<b>C. Single Replacement</b>		
4. Zn + HCl		
5. Zn + $\text{CuSO}_4$		
<b>D. Double Replacement</b>		
6. $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{Na}_3\text{PO}_4$		
7. $\text{Na}_2\text{SO}_3 + \text{HCl}$		

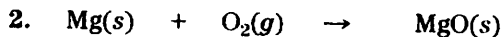
AF  
Name \_\_\_\_\_

# 14 Types of Chemical Reactions (continued)

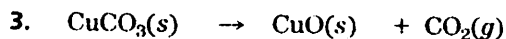
## Equations

Balance each of the equations by inserting the proper coefficients where needed. Write the names of the reactant(s) and product(s) below the molecular equation for each reaction.

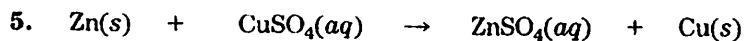
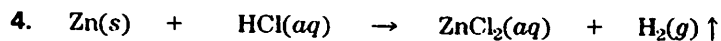
### PART A SYNTHESIS



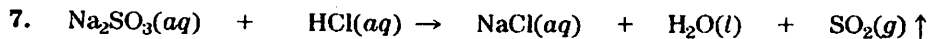
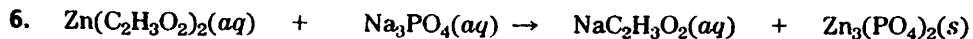
### PART B DECOMPOSITION



### PART C SINGLE REPLACEMENT



### PART D DOUBLE REPLACEMENT



## Conclusions and Questions

1. In this experiment, what method was used to test for the presence of  $\text{CO}_2$  gas? What is another test for  $\text{CO}_2$  gas? Write a balanced equation for this test.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

AF

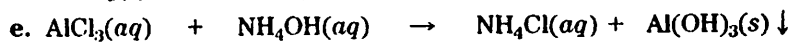
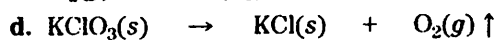
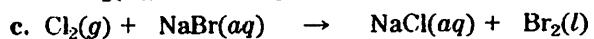
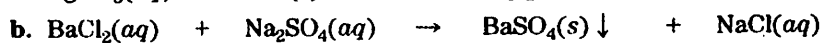
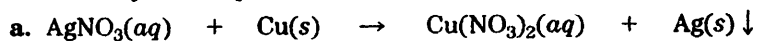
2. What test was used to identify hydrogen gas? Write a balanced equation to represent this test.

---

---

---

3. Balance the equations below and identify the type of reaction represented by each equation.



---

---

---

---

---

---